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Open when, why, to whom? Changing challenges, perspectives and practices in a new research culture

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Published in
Frontiers in Research Metrics and Analytics

ISSN 1664-8714
ISBN 978-2-8325-3873-9
DOI 10.3389/978-2-8325-3873-9

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Open when, why, to whom? Changing challenges, perspectives and practices in a new research culture

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Citation

Mugnaini, R., Urs, S. R., Fradkin, C., eds. (2023). *Open when, why, to whom? Changing challenges, perspectives and practices in a new research culture*. Lausanne: Frontiers Media SA. doi: 10.3389/978-2-8325-3873-9

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frontiers | Frontiers in Research Metrics and Analytics

TYPE Editorial
PUBLISHED 17 October 2023
DOI 10.3389/frma.2023.1303941

OPEN ACCESS

EDITED AND REVIEWED BY
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RECEIVED 28 September 2023
ACCEPTED 02 October 2023
PUBLISHED 17 October 2023

CITATION
Mugnaini R, Fradkin C and Urs S (2023) Editorial: Open when, why, to whom? Changing challenges, perspectives and practices in a new research culture. *Front. Res. Metr. Anal.* 8:1303941. doi: 10.3389/frma.2023.1303941

Editorial: Open when, why, to whom? Changing challenges, perspectives and practices in a new research culture

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KEYWORDS

open science, electronic publishing, scientific rigor, reproducibility, preprints, integrity

Editorial on the Research Topic
Open when, why, to whom? Changing challenges, perspectives and practices in a new research culture

The future is open science. Transparency, scrutiny, critique, and reproducibility are slowly and steadily becoming the normative principles of science. The COVID-19 crisis added steam to this new movement, which has redefined our role, as authors, researchers, and publishers. Two decades ago, the consumers of scientific publishing were peers and colleagues of the authors. With open access, the consumers now include a diverse array of people from a diverse array of backgrounds. "Transparency" and "reproducibility" are more than buzzwords of the day; they have raised the standards for scientific rigor. Metadata fields are expanding, almost every day, to the delight of information scientists. With preprints, data are available worldwide, independent of publication schedules. Communication platforms (e.g., Zoom and Google Meet) facilitate collaboration worldwide. The scientific landscape is changing.

Articles in this Research Topic address changes and challenges in the new research culture and offer suggestions for increased accountability. Hoffberg et al. share the findings of a study on visual abstracts. Using Twitter Analytics, the authors found that visual abstracts received a significantly higher number of impressions, retweets, and link clicks than their text abstract counterparts. The findings suggest that visual abstracts increase both the awareness and readership of journal publications.

Using data from the Italian Ministry of Health, Pozzo and Virgili examined the emergency readiness of local administrations in the inner areas of Italy, amid the COVID-19 pandemic. The authors contend that many administrations were underequipped with the management infrastructure required to comply with "social distancing precautions and to be effective with positive case tracking" (Pozzo and Virgili, p. 3). The authors voice the concern that Italy's handling of the pandemic was not consistent with their commitment to the 17 United Nations Sustainable Development Goals (United Nations, 2015).

The Registered Report System was designed to reduce questionable research practices and bolster reproducibility in psychology studies (Nosek et al., 2018). In an opinion piece based on the first author's real-life experience, Sasaki and Yamada question the adaptability of such a system. The authors relay that they had a protocol manuscript accepted by a journal under the condition that they deliver the full manuscript 2 months later. As the

in-principle acceptance was early in the COVID-19 pandemic, the authors were unable to conduct any laboratory experiments, and were, thus unable to meet the 2-month deadline. The authors requested a post-pandemic extension on the deadline. The journal denied their request and thereby deprived the authors of an accepted publication. This highlights the need for flexibility in protocol, within well-intentioned open science measures.

Fradkin and Mugnaini propose open science indicators (open data, open material, and preregistration) as article-specific metadata fields. The authors base their case on the inclusion of funding disclosures as metadata fields and cite its impact on the scientometric landscape. They contend that the inclusion of open science indicators as metadata fields may have an equally transformative effect on the scientific publishing community.

Turki et al. discuss the importance of Digital Object Identifiers (DOIs) and their critical role in the accessibility and discoverability of online publications. The authors contend that journals and institutions in developing nations are at a disadvantage in terms of access to and the acquisition of DOIs. Although the authors applaud the Global Equitable Membership (GEM) program launched by *Crossref* for its efforts to address this issue, they stress the need for more initiatives in this area.

These articles remind us that open science innovations must regularly be monitored and refined. Although celebration is in order for the steps we have taken, in the recent years of electronic publishing, our responsibility is to look back on those steps and review not just the distance we have traveled but the quality of the journey and the refinements we can make for future steps. As scientists, we sometimes paint a picture of the scientometric landscape as being rife with splendid innovations, without asking ourselves, "What more could we have done?" At this point in our open science journey, we must look beyond intention and assess a work that is in progress. A journey that defines its destination.

Author contributions

RM: Conceptualization, Writing—review and editing. CF: Conceptualization, Writing—original draft. SU: Writing—review and editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This work was supported by grants from CNPq (Research Productivity grant 308800/2022-2 and Visiting Researcher grant 350170/2022-3).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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frontiers in Research Metrics and Analytics

ORIGINAL RESEARCH
published: 14 October 2020
doi: 10.3389/frma.2020.564193

Beyond Journals—Visual Abstracts Promote Wider Suicide Prevention Research Dissemination and Engagement: A Randomized Crossover Trial

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OPEN ACCESS

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Specialty section:
This article was submitted to Scholarly Communication, a section of the journal Frontiers in Research Metrics and Analytics

Received: 20 May 2020
Accepted: 26 August 2020
Published: 14 October 2020

Citation:
Hoffberg AS, Huggins J, Cobb A, Forster JE and Bahraini N (2020) Beyond Journals—Visual Abstracts Promote Wider Suicide Prevention Research Dissemination and Engagement: A Randomized Crossover Trial. Front. Res. Metr. Anal. 5:564193. doi: 10.3389/frma.2020.564193

Background: Many academic institutions and journals disseminate research through social media to increase accessibility and reach a wider audience. "Visual Abstracts" are well-suited for social media dissemination, and have been adopted by some as a novel approach to increase engagement with academic content. Visual abstracts are a visual representation of key methods and findings from a traditional peer-reviewed publication. This study expands on previous research by examining the impact of visual abstracts compared to traditional text abstracts to disseminate research produced in a national research center focused on preventing Veteran suicide.

Methods: A prospective, randomized crossover design was utilized to compare Twitter posts with a visual abstract to those with a simple screen grab of the PubMed abstract ($n = 50$ journal publications). Outcomes were measured using native Twitter Analytics to track impressions, retweets, total engagements, and link clicks about 28 days post-tweet, and Altmetric It to track additional alternative metric outcomes.

Results: Visual abstract tweets were associated with a significantly higher number of impressions ($p < 0.001$), retweets ($p < 0.001$), and link clicks ($p = 0.02$) compared with text abstract tweets.

Conclusions: In line with results from prior studies, we found that visual abstracts resulted in significantly greater research dissemination and social media engagement via retweets and link clicks compared with text tweets. These findings provide further evidence that visual abstracts increase awareness and readership of journal publications, and that Twitter is an effective platform for research dissemination beyond the traditional academic researcher audience. Implications highlight the importance of social media for suicide prevention advocates, Veteran health researchers and other stakeholders to communicate research findings.

Keywords: veterans, social media, suicide prevention, twitter, open science, altmetric, randomized crossover design

INTRODUCTION

It has been 20 years since Balas and Boren (2000) stated that 86% of research findings never come to be used in health care practice and the 14% that do make it to practice will take 17 years to arrive (Balas and Boren, 2000). This is widely known as the research to practice gap. For research to have any chance of being translated into clinical practice, it must come to the attention of its intended audience (e.g., policy makers, healthcare providers, and healthcare consumers). Even the most robust research finding with clear clinical implications will have relatively little value in the world of science and medicine if it is never read. Though the importance of dissemination is widely accepted, we explore three overarching barriers that keep scientific findings buried in journals—unread, unappreciated, and ultimately unhelpful to society.

The first obstacle is the issue of readability. Plaven-Sigray et al. (2017) analyzed the readability of over 700,000 abstracts from 1881 to 2015 (Plaven-Sigray et al., 2017). They found that the readability of scientific writing is steadily decreasing, and they also posit that lower readability implies less accessibility to science, particularly for non-specialists, such as journalists, policy-makers and the wider community of stakeholders (Plaven-Sigray et al., 2017). It's easy to see that publications with low readability may cloak important findings behind difficult to comprehend academic jargon. Tim Radford, in an article published in 2011 by *Nature*, stated that "the language, form and conventions of the published scientific paper could almost have been devised to conceal information," using words that the general public will have never heard or used (p. 445) (Radford, 2011). To remedy this, he suggests that scientists step back and view their work from other perspectives (Radford, 2011).

Second, there are important limitations of more traditional print-based distribution methods. Held captive behind expensive paywalls, many publications are simply not able to be accessed by the stakeholders that rely on the research to make evidence-informed health care decisions. Open access (OA) refers to freely available scholarly literature. The OA movement pushes for more research publication content that is easy to find and use. With growing interest in the rapid dissemination of science, OA plows a wider path to research accessibility. In fact, a large-scale study of over 67 million articles assessing the prevalence and characteristics of OA found that as of 2015, at least 28% of publications are OA (about 19 million articles), and that this proportion is growing (Piwowar et al., 2018). Furthermore, OA has led to increased uptake of research. The researchers found that OA articles receive 18% more citations than average (Piwowar et al., 2018). The momentum and possibilities of OA impact is accelerating with the evolution of the internet. A 2008 study confirmed that OA nearly doubled the likelihood that mental health professionals would read relevant articles if they are freely available online (Hardisty and Haaga, 2008). However, so called "access tolls" remain a hindrance to the dissemination and implementation of research published within even the most prestigious academic journals.

The sheer volume of publications is a third daunting obstacle. The Scientific, Technical and Medical (STM) Report 2018 from the International Association of Scientific, Technical and Medical Publishers estimated that in 2018 there were three million articles published (Johnson et al., 2018). With so many published works, the onus is often on the reader to parse out what is worth attention. Even articles with interesting findings and implications can be overlooked in the growing sea of scientific literature (Bornmann and Mutz, 2015). This exponential growth leads to unmanageable amounts of information. Even if research overcomes the first two barriers and is both readable and accessible, it seems insurmountable for stakeholders to keep up with advances *in the traditional text form*.

Rapid Dissemination in a Digital World

While these obstacles are formidable, opportunities exist to make published work stand out, and the internet has indisputably changed the way researchers and organizations disseminate information. A paradigm shift in science means publications are not the endpoint, merely a point along the continuum of research communication. Researchers are mobilizing their digital presence to boost the rapid dissemination of their work and explore new opportunities to reach their peers and the wider community of stakeholders. A digital presence opens the possibilities of discoverability; therefore, many academic, scientific, governmental, health, and journal organizations have pivoted to social media as a revolutionary tool to disseminate research, increase accessibility, and reach a wider audience. Social media enables the immediate exchange of information and ideas and promises to transform how research is communicated and translated into healthcare practices.

Social media consists of many different platforms to serve diverse needs, and Twitter in particular has evolved into a central online hub for lifelong learning (Kind and Evans, 2015). Twitter is a microblogging social media outlet that allows users to post messages up to 280 characters in length. Surveys of researchers found that ∼10–15% used microblogging tools (Rowlands et al., 2011; Grande et al., 2014), and Twitter has emerged as the premiere microblogging tool in scholarly communication. Twitter is regularly used to announce new journal issues, promote individual articles, and engage with readers. Given the limited text length requirements, social media also unlocks the prospect of presenting key information from studies in a condensed, digestible format. For example, social posts can serve as a sounding board for discussing research and its implications for preventing suicide among a wide variety of stakeholders. In addition to academic researchers, Twitter garners widespread utilization among mental health professionals, as well as those with lived experience, such as individuals who have survived a suicide crisis and those who have lost a loved one to suicide. Prior work has also shown that Twitter's impact correlates with traditional citation impact (e.g., frequently tweeted articles go on to have more citations) (Eysenbach, 2011).

Rise of Visual Abstracts

"Visual Abstracts" offer a promising solution to address readability, accessibility, and draw attention to significant research. Visual abstracts are an emerging social media dissemination approach, defined as a visual representation of the

key methods and findings from a traditional journal publication[1]. The visual abstract is a subset of the graphical abstract, which first found use in the mid-1970's in chemistry journals (2011). Graphical abstracts have been shown to increase performance of manuscripts in terms of downloads, views, and citations (Pferschy-Wenzig et al., 2016).

The goal of the visual abstract is to present information in a compelling visual way that lets the viewer decide whether to pursue "the rest of the story" found within the scientific journal publication. At its heart, a visual abstract is intended to reflect the earnest desire to disseminate and share scientific knowledge[1]. Ibrahim et al. pioneered the modern day visual abstract format[1]. They outline the following guidelines and design principles when developing a visual abstract: focus on the user experience, clear purpose/focus, rapid prototyping/iterative development, thoughtful restraint, and relevant creativity[1]. In essence, visual abstracts are an attempt to make scientific content more accessible, without compromising message quality. Creating a visual abstract requires distilling concepts down to only their most important details.

Prior studies showed significant positive effects of visual abstracts to increase engagement within specific academic fields [e.g., surgery (Ibrahim et al., 2017; Chapman et al., 2019), geriatrics (Lindquist and Ramirez-Zohfeld, 2019)]. Research designs to test their impact include retrospective cross-sectional evaluation (Koo et al., 2019), as well as more rigorous randomized prospective approaches (Ibrahim et al., 2017; Chapman et al., 2019). In the landmark study testing visual abstracts, Ibrahim et al. (2017) conducted a prospective case-control crossover study of *Annals of Surgery* publications (Ibrahim et al., 2017). This journal is the world's most referenced surgery journal, and they found a strong correlation between the use of visual abstract tweets and increased dissemination on social media (Ibrahim et al., 2017).

Although visual abstracts originated in the field of surgery in July 2016, they have since been adopted as a novel approach by a growing body of institutions into routine journal practices[1]. Diverse disciplines utilizing visual abstracts include nephrology (Colbert et al., 2018), venous and lymphatic (Gloviczki and Lawrence, 2018a), vascular, rectal, and head/neck surgery (Nikolian and Ibrahim, 2017; Gloviczki and Lawrence, 2018b; Villwock and Johns, 2018), transplantation (Henderson et al., 2019), gastroenterology (Ibrahim, 2018), urology (Koo et al., 2019), and cardiovascular (Ibrahim and Bradley, 2017) research. Perhaps most notably, the New England Journal of Medicine regularly incorporates visual abstracts into Tweets about new scholarly publications[2].

However, widespread implementation remains limited to specialized fields of science, and is particularly nascent in mental health. While webinars are available with anecdotal reports regarding the use of visual abstracts in Veterans health research domains (Connelly and Gilmartin, 2019), the authors are not aware of any published research that evaluated visual abstracts in the realms of both Veterans and mental health/suicide prevention.

Aims of the Current Study

In the fall of 1997, Congress commissioned the Department of Veterans Affairs (VA) to establish Mental Illness Research, Education and Clinical Centers (MIRECC) with the goal to "decrease the time it takes clinical best practices to move from the literature to daily clinical practice (p. 119)"(Bryan et al., 2019). The Rocky Mountain MIRECC was established in 2004, and part of its mission is to disseminate useful information about suicide prevention in ways that are accessible to Veterans and the community at large, as well as evaluate strategies to translate research-informed practices into everyday care (Bryan et al., 2019).

Given the sustained rise in suicide rates among both Veterans and non-Veterans in the U.S. over recent decades (Hedegaard et al., 2020), innovations in suicide prevention are more urgent than ever. Consequently, this study was undertaken to evaluate the extent to which a Twitter dissemination strategy using visual abstracts influences outcomes on awareness and readership of Rocky Mountain MIRECC journal publications covering Veterans' mental health, suicide prevention, and related topics. Suicide prevention is particularly ripe for the implementation of novel dissemination tactics, as it is imperative that a broad range of stakeholders both within and outside academia remain current on research that advances best practices.

The current study tests a strategy to reach a wider audience in suicide prevention research, and extends the limited body of literature to help organizations, including the VA, understand the potential impact of implementing visual abstracts into research communication. While prior research has focused on creating and disseminating visual abstracts for specific journal content, there are some key distinctions this study adds to the literature. First, this study covered published research spanning many journals. Specifically, Rocky Mountain MIRECC publications represent multidisciplinary topic areas and audience interests, including public health, neuroscience, rehabilitation, psychology, social work, counseling, and microbiology, among others. These audience segments differ from the more homogenous audience in previous studies (e.g., Surgery). Furthermore, unlike academic journals, healthcare systems and organizations have a direct line to providers and patients and therefore are uniquely positioned to engage a broader group of stakeholders than those who normally subscribe to academic journals. In fact, large portions of suicide prevention audiences (e.g., individuals with lived experience) do not subscribe to medical journals. By extending this strategy to healthcare organizations who interact with patients, families, providers, advocates, and policy makers, we sought to communicate timely research outputs from our center in a public and accessible way. Moreover, this effort is part of a larger strategy focused on using social media to communicate and raise awareness about Veteran's mental health research topics and resources to prevent suicide.

The aim of this study is to test the effects of incorporating visual abstracts into Rocky Mountain MIRECC social media

[1]Use of a Visual Abstract to Disseminate Scientific Research. Available online at: www.SurgeryRedesign.com/resources.

[2]Visual Abstracts. Available online at: https://www.nejm.org/multimedia/visual-abstracts.

dissemination efforts. We expand on previous work by outlining a reproducible approach including examples and self-guided training that could be adopted by other researchers and organizations in which dissemination and timely communication of research findings is a key part of their mission.

Research Questions

The study research questions were (see **Supplemental Table 1** for definitions): Compared with text abstract tweets, are visual abstract tweets associated with an increased number of times the:

- Tweet is seen (impressions[3]–primary outcome)?
- Tweet is shared (retweets[3]–secondary outcome)?
- Article link is clicked (link clicks[3]–secondary outcome)?

In addition, we aimed to examine how visual and text abstract tweets impact alternative metrics attention scores (Altmetric[4]–outcome). In *post-hoc* analyses, retweets were assessed to identify engagement and reach to practitioners and others on Twitter such as those with lived experience in the suicide prevention community.

METHODS

This research was conducted and reported in accordance with the Consolidated Standards of Reporting Trials (CONSORT) extension to randomized crossover trials (Dwan et al., 2019). A completed CONSORT checklist is available (see **Supplemental Table 5**).

Ethics Approval

This study was reviewed and approved by the Colorado Multiple Institutional Review Board (COMIRB) and by the VA Eastern Colorado Healthcare System (ECHCS) Research and Development ethics committee. The protocol was determined to be not human subjects research and therefore exempt from clinical trial registration.

Study Design

A prospective, randomized two-period crossover trial was conducted to randomize ($n = 50$) journal publications comparing Twitter posts with a visual abstract to those with a text abstract, defined as a simple screen grab of the PubMed abstract. Publications were block randomized, with a 1:1 allocation ratio, to either the visual abstract first condition, or the text abstract first condition, followed by a 28-day washout period and crossover to the other condition (see **Figure 1**). This extended washout period limits any crossover contamination effects and the length is consistent with Ibrahim et al. (2017) and research suggesting that the average half-life of a tweet is only 24 minutes[5]. The randomization scheme contained random block sizes and was created by the study biostatistician (JF) using PROC PLAN in SAS v9.4. For the fourth publication randomized, an error was made such that the visual abstract was tweeted first but the publication was in the text first condition. Upon discovery, the next publication randomized to the visual first condition was changed to the text first condition to maintain balance by the end of the study.

Eligibility Criteria

Articles were included if the publication was indexed in PubMed, had at least one author with a Rocky Mountain MIRECC affiliation, and was published on or after June 1, 2018 according to the PubMed Published Date or Create Date. Publications were excluded if there was no full text access available or if the Rocky Mountain MIRECC @RMIRECC Twitter account had previously posted about them prior to study commencement. Publications were sequentially enrolled from a custom PubMed alert that searched for all known Rocky Mountain MIRECC investigators. Due to the criteria informing the PubMed query, all studies that returned in the alert met eligibility criteria and were sequentially enrolled. Study enrollment commenced June 1, 2018 and concluded April 4, 2019 when the recruitment goal was met ($n = 50$) (see **Supplemental Table 2** for all included publications).

Visual Abstract Creation

Following publication enrollment, articles were assigned to a member of the research team for visual abstract creation. There is not enough space on a visual abstract to write complex sentences, and ideas were translated to be conveyed visually as much as possible. Efforts were made to reduce overly scientific or technical language, and most acronyms were defined on the canvas. Each visual abstract went through an interactive review process among the research team that culminated in consensus and final approval by the senior member (NB). All visuals were reviewed by the study team before they were complete, which provided an opportunity to see the work from another's perspective and ensure coherence. The visual was informed by the publication itself and efforts were made to not consult with authors from the enrolled study. Standardized components of a visual abstract include summary and display of key questions and outcomes, citation, and creator. Examples of the highest performing visual abstracts from this study are available (see **Supplemental Table 3**).

Study Tweet Procedures

All study tweets from both conditions were required to post from the @RMIRECC Twitter account[6] according to a standardized procedure. In order to reduce the risk of bias due to confounding, all tweets included the exact title of the article, and no additional hashtags were used (e.g., we did not use #VisualAbstract), nor were potentially relevant Twitter user accounts tagged in the posts. All study tweets were posted in the morning (Mountain Standard Time).

[3]About your activity dashboard. Available online at: https://help.twitter.com/en/managing-your-account/using-the-tweet-activity-dashboard.

[4]What are Altmetrics? Available online at: https://www.altmetric.com/about-altmetrics/what-are-altmetrics/exploratory.

[5]Your tweet half-life is 1 billion times shorter than Carbon-14's. Available online at: http://www.wiselytics.com/blog/tweet-isbillion-time-shorter-than-carbon14/.

[6]Available online at: https://www.twitter.com/rmirecc

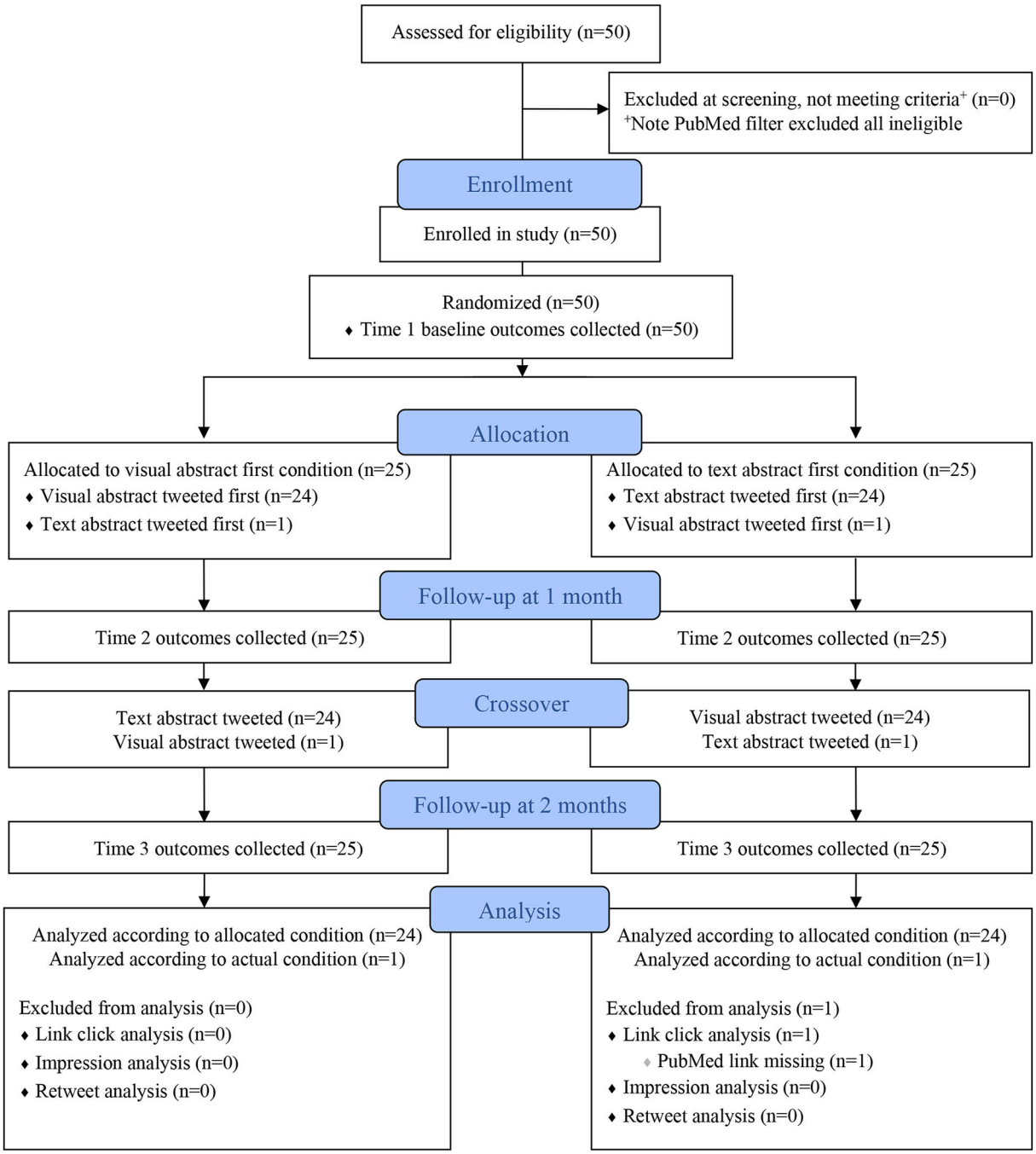

FIGURE 1 | Consolidated Standards of Reporting Trials (CONSORT) Extension to Crossover Trials Flow Diagram.

Outcome Measurement

Once the visual abstract image was approved by the study team, Time 1 baseline outcomes were measured, and then the initial tweet was posted according to the randomized allocation. Following a 28-day washout period (±3 days), Time 2 outcomes were measured, and then every article crossed over and was tweeted in the other condition, such that each article was tweeted twice, once as a visual abstract, and once as a text abstract. After a second 28-day period (±3 days), the final Time 3 outcomes were measured. Each publication was enrolled in the study for ∼2 months (see **Figure 1**).

Availability of Data and Materials

Publicly available data were collected via the Twitter and Altmetric platforms. Native Twitter Analytics were the outcome measurement source for impressions (primary outcome), retweets, total engagements, and link clicks (secondary

outcomes). Altmetric It[7] was used to measure additional alternative metric outcomes (exploratory outcome). Altmetrics are an "attention score," providing complementary data indicators of activity in online tools and environments. They count societal impact, broadly measured by mentions in news, social media, blogs, and reference manager readers. The timing of outcome measurement and data sources are described (see **Supplemental Table 4**).

Analysis Plan

This study utilized a two-period crossover design. Condition effects were determined using a crossover design specific analysis that assumed no carry-over effects, given the substantial washout period. Additionally, as the outcome measures were found to be highly non-normal, a non-parametric approach was used. All analyses assumed a two-sided test of hypothesis, a significance level of 0.05 and were run in SAS v9.4. Prior to analysis, a Fisher's exact test was used to determine if there was an association between condition allocation and who created the visual abstracts. As this was highly non-significant ($p = 0.85$), this was not considered further. The analysis of treatment effect entails taking one-half of the difference within publication and between periods, with the subtraction order dependent on the sequence (text first vs. visual first). The medians are then compared between the sequences using a Wilcoxon rank-sum test, which tests the effect of the type of tweet (Tudor and Koch, 1994). Data for total engagement was exploratory and therefore only described. Mean and median differences between conditions are presented. *Post-hoc* analyses assessed exploratory retweet outcomes for signals regarding audience reach of study tweets.

RESULTS

Visual abstract tweets were associated with a significant increase in impressions (median increase = 148; $p < 0.001$), retweets (median increase = 2; $p < 0.001$), and clicks (median increase = 1; $p = 0.02$) as compared to text abstract tweets. Median increases remained the same when the two publications affected by the randomization error were removed from analysis and significance increased slightly for all three tests (data not shown). After it became apparent that some study tweets had not been properly indexed by the Altmetric platform, Altmetric scores were determined to be unreliable, and results are therefore not presented. While not tested, the median difference in total engagements was 6, such that visual abstract tweets had a higher number of engagements. All results are presented (see **Table 1**).

In the exploratory results, we found that study tweets reached practitioners and others outside of the Rocky Mountain MIRECC scientific research community, and preliminary analyses suggested this audience may engage with visual abstract tweets more. Each visual abstract tweet was retweeted by this audience on average 2.08 times compared with 0.82 retweets for text abstract tweets.

[7]Bookmarklet for Researchers. Available online at: https://www.altmetric.com/products/free-tools/bookmarklet/.

TABLE 1 | Within abstract differences (Visual minus Text) $N = 50$.

	Mean difference (SD)	Median difference (Range)	Wilcoxon rank-sum *p*-value
Impressions	435 (830)	148 (−482, 3949)	0.0004
Retweets	2.18 (3.6)	2 (−6, 14)	0.0002
Link clicks*	1.31 (4.7)	1 (−11, 18)	0.02
Engagements	10.1 (20.0)	6 (−29, 78)	n/a

*$n = 49$; SD = standard deviation; n/a = not applicable.

DISCUSSION

This study examined a novel approach to augment the attention of Rocky Mountain MIRECC research publications. Through this randomized crossover design, both social media engagement and reach was boosted using visual abstracts. Thus, significant evidence emerged to support the ongoing implementation of visual abstracts in social media dissemination of Rocky Mountain MIRECC publications. This study tested visual abstracts produced by a government research institution whose investigators publish across a wide range of Veterans, mental health, and suicide prevention research topics catering to a multidisciplinary audience of stakeholders. A unique aspect of this study is that we sought to reach a wider audience and identify signals of engagement by non-researchers.

These positive findings are not surprising in that they reflect our relatively well-characterized affinity to process visual information. Dr. Tufte, an early pioneer in the field of data visualization, found that humans process visual data better and faster than other types of data (Tufte, 1942). Digital marketing strategists in particular have long taken advantage of this preference for visual content to engage with their consumer audience. In their commentary "#VisualAbstract: A Revolution in Communicating Science?" Wray and Arora remind us that webpages with videos and images draw, on average, 94% more views than their text-only counterparts (Wray and Arora, 2017). It is no wonder then that the visual abstract approach is spreading rapidly to many researchers and organizations.

Practical Considerations for Implementation

Since visual abstracts are relatively low effort, inexpensive, and easily implemented, and with this confirming evidence informing our efforts, the Rocky Mountain MIRECC adopted an ongoing visual abstract dissemination strategy on Twitter. Since adoption, we have published 35 additional visual abstracts to Twitter that were not part of this research study. Lessons learned moving beyond the research study include editorial discussions selecting publications for visual abstracts. The best fit are articles with generally straightforward research questions and findings, terms that don't need acronyms or complex explanation, and content with concrete concepts that translate to relatively easy visuals to complement the findings. There are also important design considerations for visual abstract creators including the selection of complementary color palettes, and applying appropriate contrast, font, and images.

Since the close of this study, we continue to refine optimal ways to present important research aspects and implications in an engaging visual way. Our approach has evolved to include tagging relevant audiences in the tweets, using #VisualAbstract and other hashtags relevant to the published content, as well as repetition of key messaging and design templates to drive home important messaging about suicide prevention across research findings.

To aid implementation by Rocky Mountain MIRECC investigators and support other organizations in this effort, a visual abstract gallery webpage was launched with examples[8], along with a self-paced, web-based training module that includes a guided "explainer" video for creating visual abstracts[9]. It is hoped that these publicly available resources will increase uptake and promote widespread adoption by others.

Strengths

The strengths of this study lie in the rigorous and reproducible methodological study design and analysis used to evaluate visual abstract impact. The standardized data measurement approach we utilized provided objective and reliable data collection for all primary and secondary outcomes via publicly available data sources, as well as complete follow-up for all enrolled studies. Additionally, the @RMIRECC Twitter account is officially verified, representing an authoritative government source for research dissemination and suicide prevention information. There are inherent social capital and reputation rewards for performing the useful service of tweeting links to new scientific articles.

The present study also extends previous research by including Altmetric attention scores as exploratory outcomes, although this source of outcome metrics inherited its own limitations described below.

Limitations

A crucial limitation of this study is its generalizability. The scope of Rocky Mountain MIRECC research and the relatively niche active Twitter followers of the @RMIRECC account do not necessarily extend to other content areas and social media platforms. Confounding also existed in that Rocky Mountain MIRECC investigators and other like-minded researchers engaged with study tweets, thereby contributing to an "echo chamber" in which findings from this study cannot necessarily be generalized to online public engagement. However, there is some evidence to suggest that study tweets did reach outside the traditional academic science researcher audience. Furthermore, due to time zone differences across followers, study tweets may have reached only a limited group of individuals.

While the incorporation of Altmetric data as an exploratory outcome is a strength of this study, it also introduced its own limitations. Although the Altmetric service is supposed to automatically pick up on online attention that uses the PubMed identifier (PMID)[10], we found that this was not always the case. Consultation with Altmetric support staff resolved the missed study tweets in question so that they were correctly captured retroactively, but no explanation was provided as to why this occurred for some tweets and not others, nor how to prevent this in the future. The inconsistent capturing of study tweets within Altmetric therefore limited the utility and reliability of the Altmetric attention score and ultimately prevented us from drawing any conclusions about the impact of visual abstracts in this domain. It remains muddled if there are better ways to link out to publications [e.g., via the digital object identifier (DOI)] to ensure that the Altmetric application program interface properly matches the mention on Twitter with the unique research output.

Considering the strict eligibility criteria for this study, no editorial stewardship was applied to decide which publication content was a "best fit" for visual abstracts. It must be acknowledged that not all published research translates well into a visual abstract format. Rocky Mountain MIRECC publications enrolled in this evaluation consisted of many study designs, including quantitative, qualitative, mixed methods, as well as reviews, commentaries, and editorials. Members of the research community, healthcare professionals, and the general public may be attracted to specific research topics, and selective approaches to reach a wider audience with more relevant studies are likely more effective. Different visual abstract design approaches and appropriate level of detail may vary depending on the intended audiences.

It is also possible that interactions with study tweets occurred without triggering engagement metrics (e.g., articles may have been navigated to outside of Twitter), therefore it is not possible to measure all Twitter Analytics outcomes with certainty.

Finally, diffusion of visual abstracts also highlights important perils. Many pitfalls exist, including the danger of oversimplification of the visual in contrast to the rigor of the research itself, biases in selecting visual content, and poor-quality crafting of the visual and/or translation of the research. The quality of the visual could impact engagement outcomes, and we had quality controls in place including a process for internal review.

Ibrahim et al. correctly remind us that visual abstracts are only meant to highlight or preview articles and are not a substitute for reading them (Ibrahim et al., 2017). Unfortunately, access to the full publication is not always possible for the Twitter audience since not all Rocky Mountain MIRECC publications enrolled in this study were OA. It is unclear how OA status may have confounded findings by impacting engagement with study tweets. However, the impact of visual abstracts on research engagement and reach may be further realized as efforts to improve access to federally funded research publications (i.e., PubMed Central) are implemented.

Future Research

Future efforts should include the study of implementation of visual abstracts at scale and refine processes to maximize engagement. Further research exploring alternative metrics as

[8]Visual Abstract Gallery. Available online at: https://www.mirecc.va.gov/visn19/education/visualabstracts.asp.

[9]Beyond Journals - Creating Visual Abstracts for Wider Research Dissemination. Available online at: https://www.mirecc.va.gov/visn19/education/visual_abstracts/creating/.

[10]How it works. Available online at: https://www.altmetric.com/about-our-data/how-it-works/.

primary outcomes is warranted. Studies should also expand in scope to determine how social media and Twitter in particular can influence the entire cycle of scientific enterprise, from idea development to communication of findings, all the way to implementation into practice and policy implications. It remains undetermined whether visual abstracts as a communication strategy lead to only superficial increases in awareness and engagement metrics, or meaningfully translate into changes in policy and/or clinical practice. That being said, it is likely that multifaceted strategies are more likely to increase awareness and translation into practice.

Future work should characterize how Twitter and alternative metric signals extend into diffusion of knowledge and changing practices. Network analyses could illuminate how research information spreads across social media networks. Furthermore, case studies tracing the path from research publication to practice implementation may shed additional light on bridging the research to practice gap. For example, we highlight a case from this study, during which a landmark suicide prevention research study was published in *JAMA Psychiatry* and enrolled in this study (Stanley et al., 2018). This large-scale cohort comparison found evidence in support of safety planning as a valuable clinical tool for suicide prevention in health care settings. The visual abstract earned 14 retweets, 5 links clicks, and 58 total engagements compared with 3 retweets, 5 links clicks, and 25 total engagements for the text tweet. Within a rapid period after publication, including widespread attention across many platforms online (Altmetric score 610 at end of study period), this study generated a clinical care policy response from the VA to scale up the intervention across facilities. Many factors contributed to this rapid implementation into practice, and the visual abstract was but one communication tool among a multi-pronged "hub and spoke" approach to help promote awareness about the effectiveness of safety planning and build momentum for widespread implementation within the VA.

As more journals and institutions turn to visual abstracts and other novel ways (e.g., podcasts) of communicating the practical implications of research findings, it will be important to examine which strategies maximize reach and impact to diverse stakeholder audiences. It will be interesting to understand how strategies synergize to achieve meaningful change.

This is especially important given the burgeoning challenges in oversaturation of media online, and future studies need to account for an audience with increasingly divided attentional time. Creative mediums such as animated Graphics Interchange Formats (GIF) visual abstracts and more sophisticated animated/whiteboard style videos may be even more fruitful and complementary strategies for the rapid dissemination of scientific research. Future research should explore these mediums.

CONCLUSIONS

In line with results from prior studies, we found that visual abstracts resulted in significantly greater reach and social media engagement via retweets and link clicks when compared with text tweets. These findings provide further evidence that visual abstracts increase awareness and readership of journal publications, and that Twitter is an effective platform for research dissemination. There are important implications highlighting novel ways to use social media as a tool for suicide prevention researchers and other stakeholders in Veterans health research to communicate findings. Visual abstracts are not a replacement for reading a full scientific article, but the format is a compelling option to increase awareness and readability of suicide prevention research. They may provide an important conduit for communicating advances in suicide prevention to a wider audience outside the scientific research community. Carefully navigating the use of visuals must distinguish effective scholarly communication from the more superficial trap of social media marketing. As scientists, we must remember that the dazzle of creative visuals rests upon the foundation of meaningful application and rigorous research content at its core.

The mission of the Rocky Mountain MIRECC is to end Veteran and all suicide. This requires that our stakeholders understand and have access to the best available evidence in support of this mission. Visual abstracts reveal possibilities for the future of scientific communication as we move beyond the journal article alone.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found here: Twitter and Altmetric platforms.

AUTHOR'S NOTE

A version of this work was previously presented: AH, JH, AC, JF, and NB (poster presentation). Beyond Journals—Using Visual Abstracts to Promote Wider Research Dissemination. 5th Biennial Conference of the Society for Implementation Research Collaboration. 2019 September 13–14; Seattle, WA.

AUTHOR CONTRIBUTIONS

AH, JH, and NB contributed to the conception of the study. AH, JH, NB, and JF contributed to the study design. AH, JH, and AC contributed to visual abstract creation. NB contributed to visual abstract feedback and approval. AH and JH contributed to posting study tweets and outcome collection. JF contributed to the analysis. All authors contributed to the interpretation of findings, as well as drafting, and revision of the manuscript. All authors contributed to the article and approved the submitted version.

FUNDING

This manuscript is based on work supported, in part, by the Department of Veterans Affairs, Rocky Mountain Mental Illness Research, Education and Clinical Center (MIRECC), but does not necessarily represent the views of the Department of Veterans Affairs or the United States Government.

ACKNOWLEDGMENTS

We would like to acknowledge Melissa McHarg and Rachel Warden of the Rocky Mountain MIRECC Education Core for their graphic design support throughout this study.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/frma.2020.564193/full#supplementary-material

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Research Metrics and Analytics

OPINION
published: 24 November 2020
doi: 10.3389/frma.2020.607257

Boosting Immunity of the Registered Reports System in Psychology to the Pandemic

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In psychology, a Registered Reports system is key to preventing questionable research practices. Under this system, manuscripts, including their detailed protocols (i.e., hypothesis, experimental design, sample size, and methods of statistical analysis), are reviewed prior to data collection. If a protocol manuscript is accepted, publication of the full manuscript including the results and discussion is guaranteed in principle regardless of whether the collected data support the registered hypothesis. However, this assurance of publication might be broken under the impact of the COVID-19 pandemic: Begrudging withdrawal of an accepted protocol manuscript due to a difficulty to meet the deadline by compelling reasons (e.g., pandemic) has occurred. The present paper reports the first author's real-life experience related to the collapse of the assurance of publication in the Registered Reports system and discusses the disbenefits of this collapse. Furthermore, we propose the implementation of a journal section specific to protocol manuscripts as a solution to the crisis of the Registered Reports system.

Keywords: registered reports, file drawer problem, idea journals, academic publishing, coronavirus disease 2019, psychology, open science

OPEN ACCESS

Edited by:
Rogério Mugnaini, University of São Paulo, Brazil

Reviewed by:
Ricardo Arencibia-Jorge, Universidad Nacional Autónoma de México, Mexico
Cristian Berrío Zapata, Federal University of Pará, Brazil

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Speciality section:
This article was submitted to Scholarly Communication, a section of the journal Frontiers in Research Metrics and Analytics

Received: *16 September 2020*
Accepted: *10 November 2020*
Published: *24 November 2020*

Citation:
Sasaki K and Yamada Y (2020) Boosting Immunity of the Registered Reports System in Psychology to the Pandemic. Front. Res. Metr. Anal. 5:607257. doi: 10.3389/frma.2020.607257

PSYCHOLOGY AND THE PRE-REGISTRATION SYSTEM

The reproducibility of studies in psychology has often been pointed out (e.g., Open Science Collaboration, 2015). The main factor is assumed to be questionable research practices (QRPs: e.g., John et al., 2012; Ikeda et al., 2019). One of the major QRPs is *p*-hacking (e.g., Simmons et al., 2011), which is the practice of seeking out *p*-values convenient for researchers (e.g., adding new data to an analysis until the results support the researchers' claim). Cherry picking is also a QRP (e.g., Fraser et al., 2018): Reporting only favorable results for researchers and ignoring or hiding unfavorable results. A third QRP is HARKing (Hypothesizing After the Results are Known: Kerr, 1988), in which researchers construct their hypothesis after the results of experiments are known to ensure a good or challenging story. These QRPs inflate the possibility of Type I error, in turn leading to low reproducibility.

A pre-registration system is one way to prevent QRPs (Nosek et al., 2018). In such a system, researchers register the detailed protocol of their studies (e.g., hypothesis, experimental design, sample size, and statistical analysis) on designated websites (e.g., Open Science Framework and AsPredicted) before they begin their experiments. They cannot modify the protocol after registration and in principle, must conduct the experiments and statistical analyses in line with the registration. However, a pre-registration system is also likely to be cracked (Pre-reg hacking: Ikeda et al., 2019; Yamada, 2018). For example, researchers can repeat experiments until they obtain results consistent

with the pre-registration ("infinite re-experimenting," "reset marathon," or "rerolling": Yamada, 2018). Researchers can also "pre-"register the protocol after the results of experiments are known (Pre-registering After the Results are Known; PARKing: Yamada, 2018). Moreover, researchers can register multiple similar protocols at numerous registration systems simultaneously and adopt only the suitable pre-registration (Ikeda et al., 2019). These pre-reg hackings (and QRPs) might occur because of the "positive results = win" mode of thinking widespread throughout the science community (Yamada, 2018), whereby a paper with positive or challenging results will be published smoothly. In any case, the pre-registration system has several drawbacks and cannot completely prevent QRPs.

REGISTERED REPORTS

Peer-reviewed pre-registration (i.e., the Registered Reports system: e.g., Nosek et al., 2018; Nosek and Lakens, 2014) compensates for shortcomings of the pre-registration system. Under this system, the manuscript including only the detailed protocol is peer-reviewed prior to data collection, and researchers must revise it if reviewers point out flaws. After the manuscript successfully passes this pre-review process (i.e., in-principle acceptance), the protocol manuscript is registered on the pre-registration websites or at each journal as in-principle acceptance (or Stage 1 acceptance), and the full manuscript including the results and discussion sections will essentially be published regardless of whether the collected data support the registered hypothesis. The Registered Reports system decreases the advantages of and motivations for QRPs and pre-reg hackings because publication is guaranteed once the protocol is accepted, and thus no positive or challenging results are necessary. The Registered Reports system can also prevent the publication bias arising when only manuscripts with positive results are published and negative results are never reported (e.g., Mahoney, 1977; Sterling et al., 1995). Moreover, the time of publication is possibly controlled to some extent because the schedule after in-principle acceptance depends mostly on researchers' activity. Taken together, the Registered Reports system has several merits that mainly stem from an assurance of publication after in-principle acceptance. However, this assurance has been broken under the impact of the COVID-19 pandemic.

A CASE REPORT OF THE ASSURANCE OF PUBLICATION BEING REVOKED

The first author (KS) and his colleagues submitted a protocol manuscript to a legitimate and trustworthy journal that fortunately had been accepted in principle just before the start of the COVID-19 pandemic (i.e., February 4, 2020, GMT).[1] In the protocol, they planned to conduct laboratory experiments requiring a relatively large sample size (N = 332 in total) and the initial deadline of the full manuscript was two months later from in-principle acceptance (i.e., April 4, 2020, GMT). However, because of the COVID-19 pandemic, they, as well as most researchers, have been rendered unable to conduct any laboratory experiments. Although the action editor kindly extended the deadline for about 5 months (i.e., until September 7, 2020, GMT), the authors cannot expect to be able to start laboratory experiments within this period, and thus they asked the action editor to be allowed to change the protocol from laboratory experiments to online ones; however, they were told that it would be necessary to withdraw and resubmit the protocol manuscript in this case because of a large deviation from the initial plan.[2] The authors then asked the action editor whether the journal could wait until COVID-19 has been contained for them to submit the full manuscript, stating that they would have been able to complete the planned experiments if they had maintained the original plan (i.e., the laboratory-experiment plan). The action editor and chief editor considered this issue, and then stated that they wished to avoid an open-ended deadline and could only extend the deadline to December 7, 2020 (or January 2021), at the maximum. As COVID-19 appears increasingly unlikely to be contained soon, prolonged or intermittent social distancing is likely to be necessary (Kissler et al., 2020), and thus it would be difficult to meet even the extended deadline. That is, the authors had no choice but to reluctantly withdraw their protocol manuscript, even though the manuscript had originally been accepted in principle and publication of the full manuscript had been promised. As indicated above, there was no fault on the part of the authors and no provision regarding this issue in the submission guidelines, whose contents remain unchanged after the authors received the editorial team's opinion, just as, so to speak, sane online-game players have been banned although they had played within the rules. Thus, this case indicates that the assurance of publication after in-principle acceptance via the Registered Reports system can collapse due to unpredicted events such as COVID-19.

The case of begrudging withdrawal of an accepted protocol manuscript due to a difficulty to meet the deadline by compelling reasons (e.g., pandemic) should be avoided because researchers in such situations might twist the data to forcibly meet the deadline. This defeats the purpose of the Registered Reports system, which was intended to increase transparency and prevent misconduct and QRPs. Moreover, the withdrawal of an accepted protocol manuscript is tantamount to losing a peer-reviewed article from one's research history, which would be a terrible blow particularly for Early Career Researchers (ECRs).[3] Furthermore, no assurance of publication after in-principle acceptance might reduce researchers' motivation to submit their manuscript to the

[1]We have no intention of criticizing a specific journal. This opinion piece is provided in an effort to improve the Registered Reports system based on our experience on this occasion.

[2]In several studies of our authors' groups, changes of protocol from laboratory to online experiments were admitted. Approval of protocol changes from laboratory to online experiments might depend on the purpose and methods of the studies.

[3]The first author obtained his Ph.D. 4 years ago and thus is also an ECR.

Registered Reports section, hampering the operation of this system. As this unintended withdrawal of registered reports might occur not only under the impact of the COVID-19 pandemic, solutions are necessary.

POSSIBLE SOLUTIONS TO THE UNWILLING WITHDRAWAL OF ACCEPTED PROTOCOL MANUSCRIPTS

How can we solve the problem of the withdrawal of registered reports? A simple solution would be for journals to flexibly extend the deadline for an indefinite time. However, an indefinite deadline might cause some disbenefits for journals; in the case of the first author, the editorial team clearly stated that an open-ended deadline would not be desirable. Indeed, if a long time passed after in-principle acceptance, it is unclear whether the same editors and reviewers would be available to review the same manuscript again, which would introduce confusion into the publication process. Perhaps, then, an open-ended system should be implemented? For example, a good solution might be for the protocol manuscript to be published by itself upon acceptance and other researchers can perform experiments in line with the protocol and publish manuscripts consisting largely of the results and discussion. This idea is based on the notion of a division of labor between the pre-registration and experimental groups in the Registered Reports system (Yamada, 2018; Ikeda et al., 2019; Yamada, 2020). In particular, because most researchers cannot perform laboratory experiments during the COVID-19 pandemic but will still have many interesting ideas, there might be a great demand for a journal section dedicated to protocol manuscripts. Moreover, a previous study suggests that a specific journal section for protocol manuscripts is easily realizable through micropublishing (Yamada, 2020). If a journal section specific to protocol manuscripts is implemented, the problem of the withdrawal of registered reports will disappear.

A journal section specific to protocol manuscripts would appear to offer benefits after the end of the COVID-19 era. It is possible that if hypothesis builders and experimenters are different, pressures for QRPs will be largely eliminated (Yamada, 2020). Moreover, many research groups are likely to conduct the same experiments simultaneously, which will ease and speed up the confirmation of the robustness of effects; this is similar to multi-lab replication (e.g., Klein et al., 2014; Ebersole et al., 2016; Klein et al., 2018). Additionally, although at this time only all-rounders (i.e., those who can build interesting hypotheses and have the skills to perform the experiments and complicated analyses) can come under the spotlight in psychology, the establishment of flexible research structures based on the division of labor will make it easier for different types of researchers to flourish in academia (Yamada, 2019). Briefly, the creation of journal sections dedicated to protocol manuscripts and the resultant division of labor are keys to resolving current problems in the psychology community.

CONCLUSION

The Registered Reports system is highly beneficial to psychological science by promoting transparency and reproducibility. Assurance of publication after in-principle acceptance is central to the Registered Reports system. Therefore, the collapse of this assurance means the death of this system. A journal section dedicated to protocol manuscripts would help resolve the crisis in registered reports. This proposal should make the Registered Reports system more flexible and thus, the system possibly comes to function properly under various kinds of unexpected situations (eg, pandemic). Last but not least, thanks to the valuable efforts of the editors of both journals, the in-principle acceptance of our protocol manuscript has been transferred to another journal (Chambers, 2020; Sasaki et al., 2020). This should be the first case of a cross-journal transfer of the registered reports. With this case as a start, the Registered Reports system might develop into the one detached and free from journals.

AUTHOR CONTRIBUTIONS

KS: Conceptualization, Funding Acquisition, Project Administration, Resources, Writing—Original Draft, and Writing—Review and Editing. YY: Conceptualization, Funding Acquisition, Supervision, Resources, Writing—Original Draft, and Writing—Review and Editing.

FUNDING

The present study was supported by JSPS KAKENHI (JP19K14482 to KS, and JP16H03079, JP17H00875, JP18K12015, and JP20H04581 to YY).

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Research Metrics and Analytics

BRIEF RESEARCH REPORT
published: 15 January 2021
doi: 10.3389/frma.2020.602200

Community Readiness for Local COVID-19 Management

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The experience of COVID-19 has highlighted the strategic role of local administrations, in all areas of service, in directing and coordinating actions to contain the pandemic. In this brief research report, we have interpreted the theme of the issue Open when, why, to whom? Changing challenges, perspectives, and practices in a new research culture by transferring it into a local context, namely in Italy's inner areas, whose communities had already endured the 2016–2017 seismic swarm. We will look into the issue pragmatically, because we think that in front of a COVID-19 induced fast-changing institutional environment, science and technology studies researchers have some ideas to offer. These days, we are learning important lessons in citizen science. Today, local administrators must equip themselves with the management of infrastructures (unimaginable before COVID-19) for enforcing social distance and tracking positive cases. One of the tasks that we wish to take up is determining the levels of societal readiness and the levels of integration in society of new technologies, products, and services. The pandemic requires social and cultural innovation policies that make communities ready to respond to catastrophic events on their territory—our case-study is Italy's inner areas—through access to data, communities of practice, co-creation, reflection, and inclusion. Finally, COVID-19 ought not to undermine the work done so far to achieve Sustainable Development Goal 1 (Poverty), 3 (Health), 4 (Education), 5 (Gender), 6 (Water), 8 (Work), 10 (Inequalities) and 16 (Peace). Pope Francis has made it clear: "This is the moment to see the poor."

Keywords: community readiness, disaster risk reduction, cultural innovation, research infrastructures, responsible research and innovation, societal readiness levels, technology readiness levels

OPEN ACCESS

Edited by:
Rogério Mugnaini, University of São Paulo, Brazil

Reviewed by:
Panayiota Polydoratou, International Hellenic University, Greece
Marcos Mucheroni, University of São Paulo, Brazil

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Specialty section:
This article was submitted to Scholarly Communication, a section of the journal Frontiers in Research Metrics and Analytics

Received: *02 September 2020*
Accepted: *10 December 2020*
Published: *15 January 2021*

Citation:
Pozzo R and Virgili V (2021) Community Readiness for Local COVID-19 Management. Front. Res. Metr. Anal. 5:602200. doi: 10.3389/frma.2020.602200

INTRODUCTION

The experience of COVID-19 has highlighted the strategic role of local administrations, in all areas of service, in directing and coordinating actions to contain the pandemic. In this brief research report, we have interpreted the theme of the issue Open when, why, to whom? Changing challenges, perspectives, and practices in a new research culture by transferring it into a local context, namely in Italy's inner areas, whose communities had already endured the 2016–2017 seismic swarm. We will look into the issue pragmatically because we think that in front of a COVID-19 induced fast-changing institutional environment, science and technology studies researchers have some ideas to offer to assist communities with taking highly technical decisions in crisis and relief situations.

The impact of COVID-19 on society is receiving enormous attention from whom is involved in research and innovation. The pandemic is not the first, and it will not be the last of the twenty-first century, but already today, we can consider it as the most significant science communication experience in the history of the world. In the media, we are witnessing an explosion of initiatives of

citizen science, the "science of ordinary citizens" or the "science without scientists" (Irwin, 1995); and we can say that the pandemic invites us to rethink the indicators of Responsible Research and Innovation (Archibugi, 2014) for a re-determination of the effectiveness in the exchange between the knowledge of scientists and the experiential knowledge of communities (Foray, 2012). At this juncture, one of the tasks that researchers in the social sciences and humanities can take upon themselves is verifying the Societal Readiness Levels, i.e., the levels of integration into society of new technologies, products, and services (IFD-Innovation Fund Denmark, 2019).

It is up to governments to establish rules to contain the contagion, and it is up to scientists to propose recommendations based on datasets that are identified and made gradually available. Nobody can rule out that, in the future, equally contagious and more lethal viruses might endanger the lives of millions of people in every corner of the planet. For this reason, we must brace ourselves. And it is about community readiness that we want to discuss in this article.

MATERIALS AND METHODS

A community is a structure that inhabits an area with determined geomorphological, social, political, and economic characteristics (Sartori, 2017: 47). Communities are at many different stages of readiness for implementing programs, and this readiness is a significant factor in determining whether a local program can be effectively implemented and supported by the community (Edwards et al., 2000, 291).

Measures that ensure the preparedness of a community fall within the framework of health prevention and are mandatory or required by law. In contrast, the government cannot impose any of the processes that induce the readiness of a community to accept new contents and processes. In Italian inner areas, recent surveys have provided qualitative and quantitative data to establish how far communities are ready to tackle the effects of natural disasters by signing up for additional insurances, taking up new mortgages, and subscribing to further services for utilities (Russo and Scagliarini, 2017), which communities did not do in compliance with the law, but voluntarily.

We can measure the effectiveness of the exchange between the scientific community's knowledge and the experiential knowledge of the general public according to increasingly precise indicators that range from no-awareness to professionalization—stage after stage—through denial, vague awareness, preplanning, preparation, initiation, stabilization, confirmation, and expansion (Edwards et al., 2000, 298–300). Today, the COVID-19 pandemic makes it urgent to revisit this dimension of the knowledge economy (Foray, 2006), highlighting the institutional mechanisms that make it efficient in producing cumulative and reliable knowledge as public goods.

Education, research, and innovation form a triangle that becomes a square if we add the fourth side: society. Nor can we deny the existence of injustice in the distribution of knowledge, education, and communication, what Miranda Fricker (2007) calls epistemic injustice. In this context, it is useful to keep in mind that the need for expressions of citizen science implies a connection to the "fragility of experiential knowledge," i.e., the knowledge that—although not scientific—is produced through the experience activity of the laity. Experiential knowledge—Dominique Foray has stated—is local, since it arises from particular experiences and applies to very particular contexts. It is fragile, since not only are few people who possess it, but as it does not have a comprehensive codification, it is not easy to transmit it, and it disappears when the people who activated it disappear (Foray, 2012: 272–273).

DISCUSSION

Emergency management puts the usual division of roles and responsibilities under stress. Public officials must have precise knowledge of the specific normative framework in which they operate, specific mandates and associated role responsibilities, and the special normative tools contemplated by the system to deal with emergencies. It is up to local administrations to raise risk-awareness, despite the different perceptions that citizens have of its immediacy and the different conditions that make it possible to involve stakeholders. In Italy, we have found similar experiences in response to natural disasters, such as in response to the 2016–2017 seismic swarm in Emilia-Romagna (ENERGIE, 2019).

The definition of an action protocol in emergency conditions is not sufficient to guarantee the actions' effectiveness. There is also a need for practices that mobilize the intervention of individual employees of public administrations who are coping with conditions in which chains of command and purely hierarchical-organizational relationships might be interrupted or with skills that would no longer be available in ordinary conditions. Municipalities that had already developed an emergency plan (in the wake of natural disasters) have proven to be more ready and effective in dealing with the pandemic's specific risk conditions (Pagliacci and Russo, 2019a). In the following sections, we will discuss integrating such actions into the current understanding of community readiness and how it advances current views.

Vulnerability

The uneven geographic distribution of COVID-19 remains an enigma in Italy, given the intense flow of movements between regions before the isolation measures. We are facing irregular patterns of geographical distribution. However, the data collected so far indicate that air pollution in the various regions (for example, the fine dust in Lombardy) determines causal links that have significant implications for the spread of the virus (Becchetti et al., 2020).

A community can be more or less resilient (Cutter et al., 2014). The resilience of a community improves by a proper assessment of local hazards and vulnerabilities. Under social and material vulnerability, "we commonly mean the exposure of some segments of the population to risk situations, understood as

the uncertainty of their social and economic condition" (ISTAT-Istituto Nazionale di Statistica, 2020).

The analysis of local exposures and vulnerabilities suggests that communities tend to be spatially linked risks (UNDRR-United Nations Office for Disaster Risk Reduction, 2020). Socio-economic research can elaborate analytical insights into specific and geographically defined risks by using data with different spatial granularity produced by various official sources, to allow its use in combination with data on exposure and vulnerability (Pagliacci and Russo, 2019b).

In Italy, epidemiological data about COVID-19 are daily collected by the regional institutions that send them to the Italian Ministry of Health. The Italian Ministry of Health, in turn, sends the data to the Italian Civil Protection Department (Italian Civil Protection Department et al., 2020), which is the government agency entrusted with driving rapid response and informed decision-making during emergencies. Thanks to the accurate and quick availability of data, Italian central and local administrations are able to provide careful assessments of the severity, spread, and impact of the pandemic to implement efficient and effective response strategies, as it has been shown for many countries beyond Italy (RDA-Research Data Alliance COVID-19 Working Group, 2020).

The need for timely and accurate collection, reporting, and sharing of data within and between research communities, public health practitioners, clinicians, and policymakers has been met quite soon. The issue is building processes that can create a lasting coalition around the goals needed to reduce vulnerability. Dedicated to social and material vulnerability and resilience of communities exposed to natural hazards is Italy's REDI consortium (an acronym for REducing Risks of Natural Disasters), which has its seat at the University of Camerino and which also includes the National Institute of Nuclear Physics, the National Institute of Geophysics and Volcanology and the Gran Sasso Science Institute. REDI is a research, innovation, and training center. Its mission is to contribute to the development of interdisciplinary research for improving preparedness and readiness to respond to disasters by communities, decreasing their recovery and recovery times. It is currently carrying out projects on re-qualified built environment, on community resilience and risk awareness, on education, training and engagement for disaster risk reduction for communities struggling to recover from natural disasters (REDI-REducing Risks of Natural Disasters, 2020).

Finally, a public debate on lessons learned from the first phases of COVID-19 management is currently taking place in Italy because the perception of a lack of coordination has emerged between political and scientific levels and institutional claim-makers, and the media (Ruiu, 2020).

Preparedness

The reference definition for community preparedness in the face of epidemiological risks was proposed by the U.S. Centers for disease Control and Prevention in 2018 and updated in January 2019:

Community preparedness is the ability of communities to prepare for, withstand, and recover from public health incidents in both the short and long term (CDC-Centers for Disease Control and Prevention, 2019).

Administrations at national, regional, and municipal levels, as well as local and territorial stakeholders, are responsible for preparing communities to do their part in supporting the development of public health, health care, human services, mental/behavioral health, and environmental health systems that support the community preparedness. Communities need to be made aware of preventing, responding to, and recovering from incidents that adversely affect public health (CDC-Centers for Disease Control and Prevention, 2019).

Readiness

In 2013, the International Standard Organization published the Technology Readiness Levels, a list of indicators capable of assessing the level of maturity of a given technology (ISO-International Organization for Standardization, 2019). That said, the Technology Readiness Levels (ISO-International Organization for Standardization, 2019) must be accompanied by the corresponding Societal Readiness Levels (IFD-Innovation Fund Denmark, 2019), which are a list of indicators that assess the level of social adaptation—or put in other words—that evaluate how a particular project, technology, product, process, intervention or innovation (social or technical) finds ways for integration into society.

Returning to COVID-19 and taking territory as a reference (region, metropolitan city, province, internal area), today, we know that local administrations must equip themselves with management infrastructures that were unimaginable before COVID-19 in order to comply with social distancing precautions and be effective with positive case tracking.

RESULTS

Community readiness is about fostering epistemic responsibility, whose effectiveness can be measured in terms of community engagement and accountability relationships. At the local level, the availability of correct information to people with relevant competencies and skills, at the right time and in the right form, is a key dimension in coping with emergencies. Typically, conflicts arise about whether, how, and when to distribute information. In this respect, Italian inner areas have faced critical situations. It has been shown that a proper assessment of local hazards and vulnerabilities can enhance community resilience (Pagliacci and Russo, 2019a).

At the European level, Pan-European Privacy-Preserving Proximity Tracing (PEPP-PT) and Decentralized Privacy-Preserving Proximity Tracing (DP3T) have become an issue. Both the European Parliament and the European Commission have adopted a firm position on safeguarding privacy in the fight against COVID-19.

According to an SWG survey published by Corriere della Sera at the climax of the COVID-19 spread in Italy, on March 30, 2020, it appears that 1) 63% of Italians agree that the state can control the movements of citizens even without their consent; 2) 64% agree on the hypothesis of putting the electronic bracelet on

people who are in quarantine; 3) 67% accepted that mobile phones are used to check whether or not people are complying with the bans; and finally 4) that 74% have nothing to object to the use of drones to control the movement of people on the street (Arachi, 2020).

Legal Basis

The reference text is paragraphs 25–26 of the Siracusa Principles on the Limitation and Derogation of Provisions in the International Covenant on Civil and Political Rights:

[§25] Public health may be invoked as a ground for limiting certain rights in order to allow a state to take measures dealing with a serious threat to the health of the population or individual members of the population. These measures must be specifically aimed at preventing disease or injury or providing care for the sick and injured. [§26] Due regard shall be had to the international health regulations of the World Health Organization (Siracusa, 1985).

Communities should consider biometric surveillance as a temporary measure taken during a state of emergency, to be repealed once the emergency is over. Nevertheless, temporary measures have "the bad habit of becoming lasting, especially since there is always a new emergency on the horizon" (Harari, 2020).

Social Innovation

As the emergency increases, the need for transparency grows. If society's readiness for a specific social or technical solution is low, measures should induce a natural transition toward social adaptation. The lower the social adaptation, the better the transition plan must be. SRL 1 is the lowest, and SRL 9 is the highest level:

SRL 1—identifying problem and identifying societal readiness SRL 2—formulation of problem, proposed solution(s) and potential impact, expected societal readiness; identifying relevant stakeholders for the project SRL 3—initial testing of proposed solution(s) together with relevant stakeholders SRL 4—problem validated through pilot testing in relevant environment to substantiate proposed impact and societal readiness SRL 5—proposed solution(s) validated, now by relevant stakeholders in the area SRL 6—solution(s) demonstrated in relevant environment and in co-operation with relevant stakeholders to gain initial feedback on potential impact SRL 7—refinement of project and/or solution and, if needed, retesting in relevant environment with relevant stakeholders SRL 8—proposed solution(s) as well as a plan for societal adaptation complete and qualified SRL 9—actual project solution(s) proven in relevant environment (IFD-Innovation Fund Denmark, 2019).

In the case of natural disasters, and such is the pandemic, at issue is how to set into motion social and cultural innovation processes that prepare communities to respond to catastrophic events on their territory through access to data, participation in communities of practice, co-creation, reflection, and inclusion (Pozzo et al., 2020).

Cultural Innovation

Culture is tradition—people say after the Analects of Confucius (7.1)—and does not need innovation. Today we know critical cultural innovation processes, which are recharged and reinvigorated through social innovation experiences and technological innovation paths. In order to identify useful indicators for measuring cultural innovation, an interesting approach is the one that takes up the idea of the "joint creation of value by the producer and the consumer, allowing the consumer to contribute to the construction of the service experience to adapt it to their needs" (Prahalad and Venkatram, 2000, 83).

Cultural innovation looks at reflexivity, at the individual's ability to distinguish some aspects in the indiscriminate mass of the flow of experiential content, isolate them, and focus on them (Archer, 2003). Cultural innovation also looks at inclusion within the diverse communities of civil societies due to shared experiences, common goods, and spaces for exchange (Pozzo and Virgili, 2016).

Today, more than ever, the importance of culture and creativity for society is evident. The availability of cultural content contributes to the acceptance of the other, dialogue, sharing, health, and mental well-being. It is clear to everyone that the crisis caused by COVID-19 is particularly dramatic for the cultural and creative sector, due to the sudden collapse of use and the consequent massive loss of revenue opportunities, especially for the most fragile actors. The COVID-19 crisis creates a structural threat to many companies and workers' survival, dedicated to cultural and creative production. "Sustainable business models during and after the initial crisis are imperative for the sector's survival. Leaving behind the more fragile part of the sector could cause irreparable economic and social damage" (OECD-Organisation for Economic Co-Operation and Development, 2020).

CONCLUSION

The pandemic is persisting, and the world is about to enter into the second year of struggle. The winter 2020/21 needs a great effort of responsibility and participation. For this reason, the pandemic invites us to urgently rethink the paradigm of the six keys indicated by the European Commission for Responsible Research and Innovation, which are: "engagement of citizens, gender equality, formal and non-formal science education, open science, research ethics and research integrity, governance framework" (Archibugi, 2014). Working on participatory approaches fueled by social and cultural innovation processes related to accessing data, creating communities of practices, establishing the boundaries of group use (Floridi, 2014), while fostering individual processes of reflection and collective processes of inclusion (Pozzo et al., 2020) can boost community readiness for local COVID-19 management.

It is necessary to reflect so that the pandemic's emergency does not undermine the work done so far to achieve in 2030 the seventeen United Nations Sustainable Development Goals. Sustainable development satisfies the needs of the present generation without compromising the satisfaction of those of

future generations. Among the most probable effects of COVID-19, we might look at increases in poverty of the vulnerable population due to loss of income, closure of micro, small and medium-sized enterprises, increases in unemployment and impoverishment, and difficulties in accessing quality education, which will be most consequential for women whose emancipation will be slowed down (Braun et al., 2020). Hence, we are concerned about goals 1 (end poverty), 3 (health and well-being), 4 (quality education), 5 (gender equality), 6 (water and hygiene), 8 (growth and employment), 10 (reducing inequalities), and 16 (peace and justice) (UNSDSN-United Nations, Sustainable Development Solutions Network, 2020).

The United Nations is calling for global agreement to tackle the pandemic crisis, which "risks erasing decades of progress in the fight against poverty and exacerbating the already high levels of inequality in and between countries" (UNSDSN-United Nations, Sustainable Development Solutions Network, 2020). Local administrations are the first to work on community readiness and reduce inequalities, which is also the exhortation of Pope Francis:

The coronavirus disease 2019 pandemic has illuminated inequities that have put poor people—in both low-income nations and in rich countries—at the greatest risk of suffering. Pope Francis recently pointed to that in an interview: "This is the moment to see the poor" (Braun et al., 2020, 214).

DATA AVAILABILITY STATEMENT

The original contributions presented in this brief research report are reflections on the works listed among the references. Further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

All authors have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

ACKNOWLEDGMENTS

RP and VV acknowledge the contribution of Margherita Russo and Carla Bagnoli (both University of Modena Reggio Emilia) on training for enhanced emergency response in local administrations as well as the invitation of Franco Salvatori and Simone Bozzato (both University of Rome Tor Vergata) to publish a shorter version of this paper in Italian in Documenti Geografici 3 (2020), 85–96. doi.org/10.19246/DOCUGEO2281-7549/202001_04, and their permission to republish its material. They remain in great debt to two reviewers of Frontiers in Research Metrics and Analytics for their insightful comments.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Research Metrics and Analytics

OPINION
published: 11 November 2021
doi: 10.3389/frma.2021.768428

Open Science Indicators as Metadata Fields?

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Since 2000, there has been qualitative growth in the field of scientometrics. Innovations such as the DOI and the ORCID have irrevocably changed the scientific landscape. They have enabled analyses previously unheard of, in the decades preceding the new millennium. This paper proposes open science indicators (open data, open material, preregistration) as article-specific metadata fields. The authors reference the history of funding information, from bare acknowledgements to metadata field. The authors describe the mission of the Center for Open Science, and its TOP Factor database, as well as the performance of open science badges. Possibilities for a pilot study are explored, with an acknowledgement of the complexity of this undertaking.

Keywords: open science, open science badges, metadata, transparency, scientific rigor

OPEN ACCESS

Edited by:
Siluo Yang,
Wuhan University, China

Reviewed by:
Jiban K. Pal,
Indian Statistical Institute, India

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Specialty section:
This article was submitted to Scholarly Communication, a section of the journal Frontiers in Research Metrics and Analytics

Received: *31 August 2021*
Accepted: *18 October 2021*
Published: *11 November 2021*

Citation:
Fradkin C and Mugnaini R (2021) Open Science Indicators as Metadata Fields? Front. Res. Metr. Anal. 6:768428. doi: 10.3389/frma.2021.768428

THE SCIENTOMETRIC LANDSCAPE

Since the electronic indexing of scientific publications, there has been qualitative growth in the scientometrics field. Innovations such as the DOI (2000) and the ORCID (2012) have transformed the landscape of our science. They have enabled bibliometric analyses that would have been unheard of years before. New bibliographic data sources such as Crossref (2000), Dimensions (2018), and Microsoft Academic (2016) are now challenging Web of Science and Scopus for their turf. The scientometric landscape is unfolding over time, driven by multiple stakeholders (publishers, funders, authors), from heterogeneous fields. This paper sets forth the possibility of open science indicators as metadata fields, functioning on an article-specific level.

Open Science

In 2015, Brian Nosek and 269 colleagues published the paper "Estimating the reproducibility of psychological science" (Open Science Collaboration, 2015), in which the authors attempted to replicate the findings of 100 psychology studies published in 2008 in three prestigious journals (*Psychological Science*; *Journal of Personal and Social Psychology*; *Journal of Experimental Psychology: Learning, Memory and Cognition*). Surprisingly, the authors found that while 97% of the original set of studies showed statistically significant effect sizes, this was only reproduced in 36% of the replicated studies. This disclosure rocked the foundations of the scientific community, as it questioned the viability of a large percentage of its published findings. In response, the Open Science (OS) movement was born. The movement drew upon assumptions from the five OS schools of thought (infrastructure, measurement, public, democratic, pragmatic; Fecher and Friesike, 2014) and distilled them into specific goals and aims.

The aims of the OS movement are to upgrade the accessibility, transparency, and rigor of scientific publication (Nosek et al., 2015). The key points are reproducibility and replication. As a means of communicating and quantifying these goals, the Center for Open Science (COS)

established Transparency and Open Promotion (TOP) guidelines (Nosek et al., 2015). These guidelines specify "eight modular standards, each with three levels of increasing stringency" (Nosek et al., 2015). These standards assess: 1) citation of data, code, and materials, 2) transparency of data, 3) transparency of code, 4) transparency of materials, 5) transparency of design and analysis, 6) pre-registration of studies, 7) pre-registration of analysis plans, and 8) replication.

Stakeholders

The recent expansion of the scientometric landscape is the product of three groups of stakeholders: scholarly publishers, individual authors, and funding bodies. The convergence of their activities has altered the global research infrastructure. The interaction between these entities is codependent and collaborative, and serves the infrastructure as a whole. Innovations from past years set the stage for the OS movement. The DOI and ORCID are two such innovations that were legitimized in bibliographic metadata. Their legitimization was a collaboration between these groups of stakeholders. The same groups, and the same collaborative process, can legitimize OS indicators as bibliographic metadata fields.

The Titans of Bibliographic Information[1]

Among citation databases, Web of Science (WoS) and Scopus are considered the most comprehensive and most trusted data sources. These "titans of bibliographic information" are regularly used for journal selection, research evaluation, and bibliometric analyses (Pranckutė, 2021, p. 1). Initially designed to facilitate global sharing of scientific knowledge, these databases now play key roles in academic hiring, resource allocation, education policy, and tenure (Aksnes et al., 2019; Kun, 2018; Rijcke et al., 2016). In WoS, journals are curated in the Core Collection, Current Contents Collection, and additional indices. Subscription cost is priced accordingly. In Scopus, similar content is available but with a single subscription fee and no room for modulation. Information from both databases is searchable through metadata fields, which include ORCID, DOI, and funding information. These fields facilitate search options; they impact different research cultures. Their adoption has been heterogeneous across disciplines and countries, as observed by Mugnaini et al. (2021) in relation to the DOI. Nonetheless, these recent innovations have reshaped the scientometric landscape.

Funding Information and Its Impact on the Scientometric Landscape

An illustration of this reshaping can be seen in funding acknowledgements (FA), which are now accessible in WoS and Scopus metadata. These statements are typically one sentence in length, and provide acknowledgement of the research-funding source. In the 1990s, Cronin (1991) highlighted the significance of FAs in scholarly communication, and predicted its future use in scientometric studies. By later in the decade, Wellcome Trust's Research Outputs Database (ROD) had organized funding sources from 214,000 biomedical articles (Dawson et al., 1998). Research on this trove provided evidence that articles including FA were likely to receive more citations than articles not reporting this information (Lewison and Dawson, 1998; Lewison et al., 2001; MacLean et al., 1998). In the 2000s, Giles and Councill (2004) developed an algorithm to extract and analyze FA information, and applied it to 335,000 documents in the CiteSeer computer science archive. Inclusion of FA was positively associated with citation count. In 2008, WoS began a systematic collection of FA data on funding text (FX), funding source (FO), and grant number (GN). In 2013, Scopus followed suit and began recording funding source (FUND-SPONSOR), funding source acronym (FUND-ACR), grant number (FUND-NO), and aggregated funding information (FUND-ALL) (Alvarez-Bornstein and Montesi, 2021). The inclusion of FA in these two mega-databases significantly expanded the vista of evaluative scientometric studies. In the 2010s, Díaz-Faes and Bordons (Diaz-Faes and Bordons., 2014) referred to FA indexation as a rich source of information and proposed systematic inclusion for the future. Since then, this new bibliographic field has gone through several further iterations, as is expected in such cases, under the scrutiny of the expert community (Alvarez-Bornstein and Montesi, 2021; Paul-Hus et al., 2016). Its evolution, however, is not limited to the expert community, as major funding bodies are increasingly mandating recognition of their contributions.

Another aspect of reshaping has been through public access mandates. These mandates were in response to the 2013 memorandum titled "Increasing Access to the Results of Federally Funded Scientific Research" (OSTP Memo; Holdren, 2013). Issued by the White House Office of Science and Technology Policy, the memo directed that all funding agencies with budgets over $100 million provide free access to their peer-reviewed publications. As of 2021, Google Scholar provides a public access section to their profiles, to help authors track and manage public access mandates for their articles (Sethi et al., 2021). These innovations are the product of the three main groups of stakeholders: publishers, individual authors, and funding bodies.

Open Science Indicators as Metadata Fields

The inclusion of FA fields in databases enables funders to gauge the impact of their investment. This availability contributes to a more transparent culture: one held to higher standards. These standards are aligned with those of the OS movement: higher transparency, accountability, and scientific rigor (Nosek et al., 2015). In terms of values, FA information and OS practices could be sister indicators, although their movement occurs at different

[1]Attributed to R. Pranckutė's (Pranckutė, 2021) "Web of Science (WoS) and Scopus: The Titans of Bibliographic Information in Today's Academic World," https://doi.org/10.3390/publications9010012.

levels. FA is at the article level; OS practices are at the journal/publisher level. For OS practices to serve as OS indicators, they must be conceptualized at the article level. This contextual adjustment might be helped by following the template of FA field inclusion.

Open Science Data

Since 2020, the COS has compiled data on the implementation of OS measures in their TOP Factor database (Center for Open Science, 2020). TOP Factor assesses journal policies for the degree to which they promote the eight OS norms of transparency and reproducibility. TOP Factor rates journal policies on a four-level scale, particular to each of the eight norms (Center for Open Science, n.d.-b). As of 2021, TOP Factor has tracked the implementation of OS measures among more than 900 signatories (Center for Open Science, 2021). In addition, TOP Factor tracks the implementation of OS badges. OS badges are visual icons displayed on the journal website; they spotlight transparency and scientific rigor.[2] Badges signal to the reader that the content of an article (data, materials, pre-registration) is publically available and accessible in a persistent location (Center for Open Science, n.d.-a). As a promotional tool, OS badges have been found to be effective in incentivizing OS practices (Kidwell et al., 2016). Their implementation, however, has been lagging. As of 2021, of the more than 900 journals in the TOP Factor database, only 86 offered OS badges. Of these 86, only 19 journals displayed badges in a prominent position (i.e., in the table of contents).[3] This figure could be higher, and we respectfully request that the COS consider adding a badge placement indicator to the TOP Factor scoring system.[4]

The Operationalization of Open Science Indicators

The COS promotes OS norms at the journal/publisher level. This is evident in the makeup of TOP Factor, whose signatories are for the most part journals (Center for Open Science, 2021). By contrast, OS badges are article-specific; they have potential for scientometric usage. Think DOIs, FA information, lead author's contact information. At an article level, metadata fields could contain information on the article's open data, open materials, and pre-registration—the building blocks of OS.[5] In its initial iteration, this information could be dichotomized (0 = *no*, 1 = *yes*, for open data, open material, preregistration). Further iterations could store repository information for open data, open material, and preregistration. For this task, the organization Crossref might be consulted. Crossref is a collective of academic publishers that is developing shared infrastructure to support more effective scholarly communications (Lammey, 2014, p. 84). One of their innovations, Funder Registry (FundRef until 2015), provides standardization for the reporting of funding sources for academic publications.

Future Steps

OS badges are, in essence, OS indicators. They indicate an article's compliance with OS standards. They perform this function at the article level, which makes them a valuable component for the execution of our plan. Our aim is to create dialogue about the possibility of OS indicators as metadata fields. To move forward toward our goal, articles must first be coded as to their meeting of OS badge requirements. As previously mentioned, they could be coded yes/no. As of 2021, there are less than 90 journals in TOP Factor issuing OS badges (Center for Open Science, 2021). This sample could be a starting point. With funding, we could devise a coding process, in collaboration with the editors and publishers of these journals. A pilot study of this sort could yield invaluable results, for the larger, long-term undertaking. Rough edges could be smoothed, realities fine-tuned. While these activities were in progress, the COS would be promoting OS standards among their signatories. With this parallel activity, the COS might notice that their influence was stronger, in recruiting journals to their cause. At that juncture, it would be helpful for the COS to implement a pipeline through which OS indicator information could flow. This would expand the breadth of the organization's output, from handling journal-specific-only to article- and journal-specific information.

CLOSING

OS research stands apart from other research in that it inadvertently promotes OS values. In that sense, every study examining OS standards keeps the buzzword of open science in the air. Every study published reminds us of the progress we have made, and of the many steps that lie ahead. The aforementioned pilot study could be a springboard of sorts; it could be a nexus for scholars who embrace OS values and wish to transform the research culture of the future. As of 2021, journal policies promote OS measures, although they do so to varying degrees (see Center for Open Science, n.d.-b). What is needed at this point is a core group of scholars, committed to the vision of legitimizing OS indicators as metadata fields.

We are aware of the challenges we face, in bringing this idea to fruition. We are aware of the time it took for FA information to be legitimized in bibliographic metadata—but in this digital age, we are hoping things run faster. We console ourselves that patience is required and that change does not happen overnight. Through this journey, our spirits are intact; we continue to follow our ideal. For a more transparent research culture, OS standards must move forward; OS indicators must move into the mainstream. They must be article-specific; they must be readily accessible; they must have metadata fields of their own.

[2]OS badges are not machine-readable.

[3]Badges displayed on the table of contents page receive significantly more views than those displayed in other areas.

[4]A badge placement indicator would specifiy OS badge position: table of contents, individual article page, downloadable pdf.

[5]Replication study status (yes/no) could also be contained in metadata fields.

AUTHOR CONTRIBUTIONS

CF and RM contributed to the conception and writing of the paper. Both authors read and approved the submitted version.

FUNDING

This work was supported by a grant from Fundação de Amparo à Pesquisa do Estado do Rio de Janeiro (grant E-26/201.015/2020) and CNPq (Research Productivity grant 311237/2019-3).

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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frontiers | Frontiers in Research Metrics and Analytics

TYPE Brief Research Report
PUBLISHED 17 August 2023
DOI 10.3389/frma.2023.1207980

OPEN ACCESS

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RECEIVED 18 April 2023
ACCEPTED 01 August 2023
PUBLISHED 17 August 2023

CITATION
Turki H, Fraumann G, Hadj Taieb MA and Ben Aouicha M (2023) Global visibility of publications through Digital Object Identifiers. *Front. Res. Metr. Anal.* 8:1207980. doi: 10.3389/frma.2023.1207980

Global visibility of publications through Digital Object Identifiers

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This brief research report analyzes the availability of Digital Object Identifiers (DOIs) worldwide, highlighting the dominance of large publishing houses and the need for unique persistent identifiers to increase the visibility of publications from developing countries. The study reveals that a considerable amount of publications from developing countries are excluded from the global flow of scientific information due to the absence of DOIs, emphasizing the need for alternative publishing models. The authors suggest that the availability of DOIs should receive more attention in scholarly communication and scientometrics, contributing to a necessary debate on DOIs relevant for librarians, publishers, and scientometricians.

KEYWORDS

scholarly communication, scientometrics, publishing industry, Global South, persistent identifiers, journals

1. Introduction

The availability of Digital Object Identifiers (DOIs) is of global relevance in publishing. Nevertheless, DOIs are not assigned to every publication, which limits the visibility of this subset in scholarly publishing. DOIs are a type of unique and global identifiers for digital objects, such as publications (Carter-Templeton et al., 2021). DOI registration agencies (e.g., *Crossref*) assign a DOI prefix to each publisher, which makes each article identifiable as an output of a specific publisher. Further parts of the DOI identify the venue (e.g., the journal) and the specific object (e.g., a journal article). While there are also other unique persistent identifiers, Digital Object Identifiers are important metadata elements in scholarly communication. But do all countries and their publications have DOIs? This is certainly not the case, as we will suggest below.

DOIs are used in scientometrics and related research fields, for example, to study the lists of references in publications (Mugnaini et al., 2021), or retrieve documents from repositories and match them with records in DOI registration agencies for citation analysis (Haupka et al., 2021). They can also be used to enrich bibliographic databases, such as *Scientific Electronic Library Online* (*SciELO*).[1] Additionally, DOIs can be used to conduct altmetric studies, that is, the perception of research outputs in online data sources, such as Wikipedia, Twitter, and more (Peters et al., 2016). However, DOIs are not allocated in certain journals and publishers in the Global South, except if researchers can publish their research in other international venues (e.g., journals and repositories) that provide DOIs.

1 https://images.webofknowledge.com/WOKRS513R8.1/help/SCIELO/hs_doi.html

To track the visibility and impact of scholarly publications, it is important to provide Digital Object Identifiers (DOIs) or other unique persistent identifiers for research outputs, particularly those issued by publishers in the Global South. In doing so, the visibility can be increased, for example, through a wider inclusion in altmetric sources and other sources that require unique persistent identifiers. This increased visibility was stressed in early work on altmetrics (Alperin, 2013). Do scientific publishers from the Global South have adequate DOI allocation? We want to raise awareness that the output of some scholarly publishers from the Global South is less visible in the "the global flow of scientific information" due to the lack of unique persistent identifiers, including DOIs (Mugnaini et al., 2021, p. 2524). This issue relates to previous work on the lower visibility of journals from the Global South, due to less inclusion in bibliographic databases, such as *Crossref* (Asubiaro and Onaolapo, 2023).

2. Availability of DOIs

We retrieved the list of DOI prefixes corresponding to journal publishers in *Crossref*.[2] It is true that there are DOI registration agencies beyond *Crossref*.[3] However, *Crossref* is among the largest ones, providing millions of DOIs (Hendricks et al., 2020) and having a significant representation of publishers from developing countries (Asubiaro and Onaolapo, 2023). This is why restricting our analysis to *Crossref* provides reliable results for our analysis. We decided to consider journal publishers instead of the institutions issuing conference proceedings and books/reference material reports by *Crossref*. We considered this publication type because journal articles are typically used as research data in scientometric studies. As of 17 January 2022, 98,420,414 DOIs and 103,606 source titles were reported by journal publishers. Some journal publishers and consequently DOI prefixes operate multiple journals. We only consider the 200 most published DOI prefixes including 83,472,052 DOIs (84.8%) and 37,833 scholarly journals (36.5%) for better computation and verification of data. This restriction will only have a minor influence on the output of our data collection and analysis as it captures the publishing behavior of most of the *Crossref* database. Our analysis is mainly based on the number of assigned DOIs and the considered DOI prefixes provide most of them. Afterwards, we used *OpenRefine*[4] to match metadata about the top 200 DOI prefixes in *Wikidata*,[5] an open and multidisciplinary knowledge graph providing large-scale bibliographic data (Nielsen et al., 2017), through the alignment of the publisher names with corresponding Wikidata items. A publisher can have more than one DOI prefix. But, this does not affect our analysis as we are interested in studying the whole picture of how DOIs are assigned and not in ranking the use of DOIs by different stakeholders.

When analyzing the top 200 DOI prefixes, we found out that the main DOI providers correspond to 15 large scholarly publishing houses, mostly created in the 19th century (See the *inception* column in the Table 1), such as *Elsevier* and *Springer* with a minor appearance of new publishing houses that publish open-access mega-journals such as *Public Library of Science* as shown in Table 1. This confirms the attraction of the scientific community to mega-journals due to their large research scope, rapid time to publication and their reach to a very broad audience (Björk, 2017). This also supports previous research findings about the domination of large publishing houses, particularly *Elsevier*, *Springer* and *Wiley*, on the market of scholarly publishing (Larivière et al., 2015). The oligopoly of scholarly journal publishing, which is mainly controlled by companies in developed countries, makes it difficult for developing countries to establish their own scholarly publishing traditions. This is because the publishing industry model is not adapted to the context of developing countries, which often lack funding, infrastructure, expertise, and research integrity (Posada and Chen, 2018).

The fact that developed countries are leading the scholarly publishing industry and research communities is verified by the following data. According to Figure 1 (gray bars), the United States of America, United Kingdom, Netherlands, Germany, Switzerland, France, and Japan are the main publishers of DOI items in *Crossref*. These countries are all located in the Global North, and they have a significantly higher representation in *Crossref* than domestic publishers in the Global South. This imbalance is due to a number of factors, including the long history of publishing houses in developed countries (Larivière et al., 2015; Posada and Chen, 2018), and the large market for scholarly publishing available in these countries (Posada and Chen, 2018). In recent years, however, there has been a growing trend of open access publishing in developing countries. This is motivated by a number of factors, including the increasing availability of funding for research, and the desire to increase the visibility of local research. As a result of this trend, some developing countries maintain several top 200 DOI prefixes, as depicted in Figure 1. Despite the efforts of several developing countries to expand their share in the scholarly publishing industry and assign DOIs to further publications, these nations failed to convince the worldwide research community to significantly contribute to their scholarly venues. This proves that developing countries face significant challenges to grow their scholarly publishing industries and this is what explains the gap between publishing houses in the main developed countries and the ones from the Global South (Salager-Meyer, 2008).

The disparities are not only restricted to the country representation of institutions issuing DOIs but also concerns the types of institutions providing DOIs. As shown in Table 2, scholarly publishers, scientific societies and non-profit organizations are the main establishments involved in assigning DOIs. University presses, research institutions, libraries, governments, and universities account for less DOIs in the present dataset, although some of them also provide their own scholarly publishing outlets. Asubiaro and Onaolapo (2023) also showed the relatively low share of university publishers of journals from developing countries in *Crossref*, compared to other categories of publishers. This occurs for a few reasons. First, these institutions typically publish large-scale reports, books, and book chapters (Ganu, 1999), which are more challenging to publish and disseminate than scholarly journals and conferences (Ali et al., 2013). Second, there are open-access DOI providers, such as data and publication repositories (e.g., *Zenodo*)

2 https://www.crossref.org/06members/51depositor.html

3 https://www.doi.org/the-community/existing-registration-agencies/

4 https://openrefine.org/

5 https://www.wikidata.org/

TABLE 1 Top 16 most published DOI prefixes in *Crossref* as of 17 January 2022.

DOI prefix	Name	Instance of	Country	Journal count (percentage)	Total DOIs (percentage)	Inception
10.1016	Elsevier BV	Publisher	Netherlands	4,262 (4.1%)	17,218,689 (17.4%)	1,880
10.1007	Springer Science+Business Media	Publisher	Germany	3,323 (3.2%)	6,551,598 (6.6%)	1,842
10.1002	John Wiley & Sons Ltd	Publisher	United Kingdom	1,358 (1.3%)	5,380,888 (5.5%)	1,807
10.1080	Taylor & Francis	Publisher	United Kingdom	3,736 (3.6%)	4,392,461 (4.5%)	1,852
10.1111	Wiley-Blackwell	Publisher	United States of America	1,382 (1.3%)	3,642,267 (3.7%)	2,001
10.1371	Public Library of Science	Website	United States of America	10 (<0.4%)	3,478,859 (3.5%)	2,000
10.1093	Oxford University Press	University press	United Kingdom	563 (0.5%)	3,140,580 (3.2%)	1,586
10.1177	SAGE Publications	Book publisher	United States of America	1,555 (1.5%)	2,609,787 (2.7%)	1,965
10.1021	American Chemical Society	Scientific society	United States of America	93 (<0.4%)	2,163,704 (2.2%)	1,876
10.1097	Wolters Kluwer	Book publisher	Netherlands	396 (<0.4%)	1,893,239 (1.9%)	1,987
10.1017	Cambridge University Press	University press	United Kingdom	613 (0.6%)	1,633,902 (1.7%)	1,534
10.2307	JSTOR	Organization	United States of America	748 (0.7%)	1,603,832 (1.6%)	1,995
10.1038	Springer Science+Business Media	Publisher	Germany	214 (<0.4%)	1,364,997 (1.4%)	1,842
10.1109	Institute of Electrical and Electronics Engineers	Standards organization	United States of America	397 (<0.4%)	1,294,983 (1.3%)	1,963
10.1136	BMJ	Publisher	United Kingdom	81 (<0.4%)	923,126 (0.9%)	1,840
10.1088	IOP publishing	Publisher	United Kingdom	121 (<0.4%)	914,137 (0.9%)	1,874

Springer Science+Business Media has two separate DOI prefixes in this sample. Wiley-Blackwell is a business of John Wiley & Sons Ltd.

that do not charge a fee for DOI allocation. In contrast, direct registration of DOIs in *Crossref*, the main DOI provider, is subject to a fee even for non-profit organizations and public institutions.[6] This can be a barrier for these institutions, which may struggle with funding and online payment of fees. DOIs are generated, for instance, by registering a metadata record at *Crossref*.[7] This registration process is only available for *Crossref* members, but does not differ based on geographical location of the publisher. This structure of fees might be different in other contexts that we did not consider in this brief research output with a focus on *Crossref*. Further limitations of the present study include that the overall numbers of assigned DOIs per country are not compared to the overall numbers of research outputs per country. The number of research outputs per country is also related to the number of researchers per country, which can vary to a high degree across countries. Furthermore, the location of publishers as shown in Figure 1 does not necessarily reflect the affiliation of authors. Such comparisons would be valuable, but are out of scope of this brief research report.

3. Conclusion

In conclusion, Digital Object Identifiers (DOIs) play a critical role in the accessibility and discoverability of online publications, but their availability is not equally distributed across the world. Our analysis of the top 200 DOI prefixes registered with *Crossref* reveals a dominance of large publishing houses from high-income countries in North America and Europe, with limited representation from the Global South. This has significant implications for global scholarly communication, including the visibility and adoption of metrics and indicators, and the need for alternative solutions and infrastructures. Therefore, we urge the scholarly community to address these issues by promoting the availability of DOIs globally and fostering a more inclusive and equitable scholarly communication system. Initiatives that try to tackle these issues, such as the Global Equitable Membership (GEM) program launched by *Crossref*[8] after the data collection of the present study, point toward the right direction and can make publications from several countries of the Global South, among others, more visible. Similarly, we would like to encourage more representatives from the Global South to join the DOI Foundation,[9] which would help to raise the visibility of research originating from a large part of the world. While this membership is not a requirement to allocate DOIs for publications, it would support the development of the global scholarly publishing system. Finally, planned DOI registration agencies, such as those by the Africa Persistent Identifier (PID) Alliance (Ksibi et al., 2023), that are tailored to the publications of specific world regions can increase

6 Further information can be found at https://www.crossref.org/fees/.

7 Further information can be found at https://www.crossref.org/services/content-registration/.

8 Further information can be found at: https://www.crossref.org/gem/.

9 Further information can be found at: https://www.doi.org/the-community/who-are-the-members-and-users/.

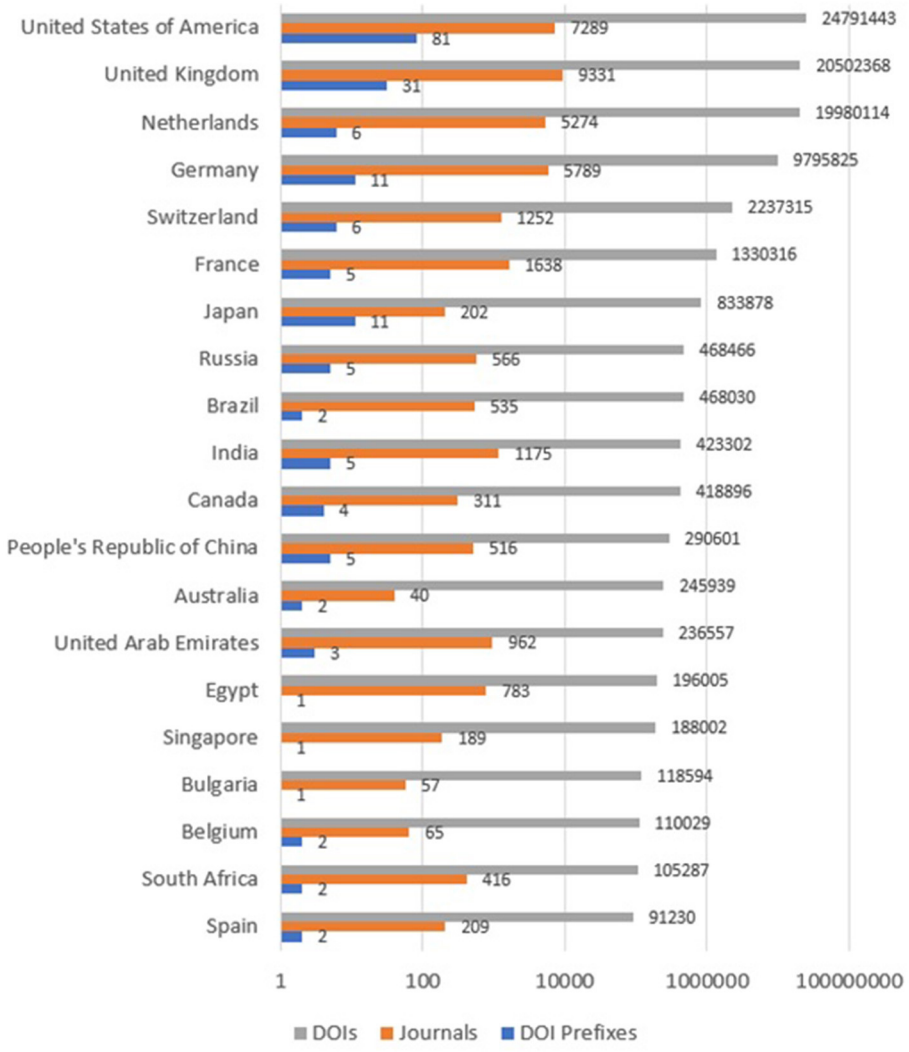

FIGURE 1
Top 20 countries assigning DOIs based on the *Crossref* Top 200 DOI Prefixes as of 17 January 2022.

TABLE 2 Types of institutions issuing *Crossref* DOIs (200 top DOI prefixes) as of January 17, 2022.

Type	DOI prefixes	Journals	DOIs
Publisher	84	28,696	55,441,839
Scientific society	54	1,532	9,192,417
Organization	29	1,613	6,281,437
University press	8	1,645	5,641,068
Repository	8	2,425	5,562,784
Journal series	7	22	644,533
Research institutions and libraries	8	1,022	457,894
Government	2	878	250,080

the visibility of publications globally. This could be a crucial step to assign more DOIs to publications from the Global South.

Data availability statement

The datasets presented in this manuscript have been uploaded to the GitHub repository and can be accessed via the following link: https://github.com/csisc/DOIPrefixAnalysis.

Author contributions

All authors contributed equally to this manuscript in its conception, writing, and editing.

Funding

The publication of this article was funded by the Open Access Fund of Technische Informationsbibliothek (TIB) and the research was funded by the German Federal Ministry of Education and Research (BMBF) under grant number 01PU17019.

Acknowledgments

We thank the peer reviewers for their valuable comments that improved the manuscript. We also thank the speakers and attendees of the 2019 Latin American Symposium on the Metrics Studies of Science and Technology (LASMSST) in Mexico City and the 2019 ENRESSH (European Network for Research Evaluation in the Social Sciences and Humanities) training school in Poznań for discussing the availability of DOIs. We also thank Stephanie Hagemann-Wilholt (TIB – Leibniz Information Centre for Science and Technology) and Zohreh Zahedi (CWTS, Leiden University) for commenting on an earlier draft of this article.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The handling editor RM declared a past co-authorship with the author GF.

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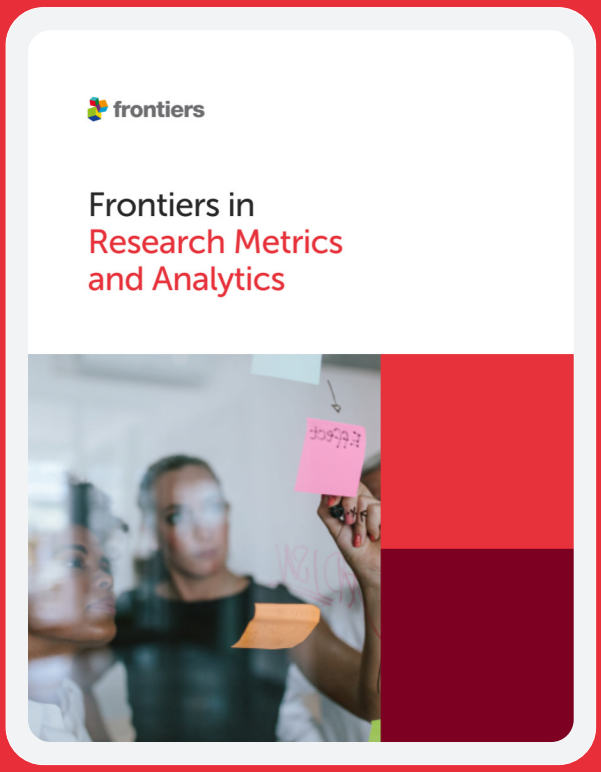

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